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THE NATURE OF PLEOCHROIC RINGS OF SMALL RADIUS

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Abstract: The data of Joly and Henderson on pleochroic rings of unusually small radius which were observed by them and ascribed to the action on mica of alpha-particles, emitted by very electrical light-resistant elements, is cited and discussed. The proposal is set forth that these rings are caused not by alpha-particles but by fragments resulting during fission of heavy elements. Further, the possibility is considered that these fragments are obtained as a result of the spontaneous fission of heavy nuclei. The rings of small radius which are observed in uranium holes could be obtained as a result of the fission of a certain unknown isotope of uranium, U_{92}^* . The spontaneous fission observed at present in uranium can be attributed to the same X-isotopy if its content in uranium is taken to be of the order of 10^{-7} to 10^{-8} %.

In a series of works, Rutherford, Joly, and Henderson (1) showed that the cause of the occurrence of concentric dark rays (pleochroic halos) observed in certain micas is alpha-particles that are emitted by natural radioactive elements. The clearly defined dark circles of various diameters were said

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to be due to the fact that ionizational losses for alpha-particles increase greatly with decrease in energy, attaining a maximum near the end of their flight. Each ring corresponds to alpha-particles of definite energy and thus the study of the halo radiuses of the rings and of their relative intensities could give certain information concerning the processes of radioactive decay that occur during the entire time of existence of mica in the solid state (of the order of 10^8 years).

The curve showing the dependence of the range of light upon distance of a given point to the center of the halo gives sharp breaks at places corresponding to flights of alpha-particles of definite energies.

For uranium, all rings, with the exception of two, $r_1 = 1.05$ cm and $r_2 = 1.3$ cm in air, were to be ascribed to alpha-particles emitted by radioactive elements of the uranic family. For thorium, one ring ($r_3 = 1.2$ cm in air) remained indefinite.

An earlier work of Joly (1) also indicated that rings of small radiuses occur sometimes to other with rings corresponding to thorium alpha-particles.

Attempts to explain these rings with small radiuses (X-rings) by means of short-range alpha-particles encountered great obstacles. The relations between the energies of alpha-particles and half-life periods of an alpha-emitting element require that heavy nucleuses that emit similar short-range alpha-particles possess a half-life period of 10^{25} to 10^{35} years; that is, they were practically stable. For lighter elements of the rare-earths type, the half-life period decreased to 10^{11} - 10^{12} years, but this quantity would still be too large to be able to explain the observed X-rings by the decay of these elements. The only possible explanation is that these rings are connected with the alpha-decay of some light-weight element not existing at present.

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In this article we should like to turn our attention to the possibility of explaining the X-rings by the action, on mica, of fragments that arise during the fission of heavy nucleuses.

As a result of the decay of heavy nucleuses during the action on them of gamma-rays, neutrons, deuterons or, finally, during spontaneous fission, there are obtained fragments possessing flight paths of 1.3 to 1.9 cm range in air (light fragments are about 1.9 cm and heavy ones are about 1.3 cm). In this case the ranges are connected by no means with the life span of the nucleus and are due entirely to the Coulomb energies of repulsion between the fragments.

The assumption concerning the fragmental nature of the X-halo permits one to explain the absence of maximum of ionization at the end of flight, characteristic (that is, maximum) for alpha-particles; of all the ionizing particles only the fragments give a small ionization at the end of flight in consequence of the decrease in effective charge. The fragments causing the X-rings could arise as a result of certain processes:

1. Heavy nucleuses - namely, uranium and thorium - could divide under the action of neutrons. The quantity of cosmic neutrons at the earth's surface is at present too small to explain the X-halo.
2. Heavy nucleuses could undergo fission spontaneously. The quantity of spontaneously decaying uranium nucleuses is so small at present that it can explain only 10^{-3} of the observed effect (2). Moreover, for the known thorium isotopes the phenomenon of spontaneous fission has generally not been observed. X-rings are observed even in thorium halos.

The X-rings can be explained by spontaneous fission if one makes a supplementary assumption - namely, to consider that uranium and thorium isotopes that are not observable at the present time do decay spontaneously. The

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decay of these lighter isotopes of uranium and thorium must occur in a very short time of the order of 10^7 to 10^8 years; and consequently the X-rings and rings observed together on photographs, that (i.e. rings) are caused by known alpha-particles, possess various ages. This fact can serve to explain why X-rings are observed not in all uranium and thorium halos.

Spontaneous fission of these hypothetical light-weight X-isotopes can be connected even with the recently observed effect of spontaneous fission in uranium. The concentration of X-isotope at present must be of the order of 10^{-9} to 10^{-10} relative to the main uranium isotope, if one proceeds from the assumption that $2 \cdot 10^9$ years ago (the age of the earth) the distribution of all uranium isotopes was equal. Such a small content of X-isotope lies far beyond the limits of sensitivity of mass-spectrographs and can be observed only in dependence upon the spontaneous fission of artificially obtained $^{233}_{92}$ - which possibly is actually this unknown X-isotope of uranium (3).

I should like to express here my gratitude to Professor I. V. Kurchatov for the interest shown in the problem under discussion and for his critical remarks.

References

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